National Aeronautics and Space Administration

FY 1987 Safety Program Status Report

NASA Safety Division
Office of Safety, Reliability, Maintainability and Quality Assurance
Washington, D.C. 20546

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SAFETY PROGRAM OVERVIEW

As part of NASA's return to flight effort, the plans made last year to develop an aggressive, centralized safety program were implemented in FY 1987. The Headquarters Safety Division staff was increased, and major emphasis was placed on risk management, institutional and program safety. The reorganization of the safety, reliability and quality assurance functions at the field installations was nearing completion at the end of FY 1987 with the same effort expected to be completed at the Jet Propulsion Laboratory in 1988.

Level I safety review and approval roles and responsibilities were established. A review of the risk management function throughout industry was conducted to aid NASA in the development of criteria for its own risk management effort. Revision and/or development of numerous safety documents was initiated in FY 1987. This will be an ongoing effort as the agency intends to develop and maintain current safety documentation for all pertinent activities.

In response to recommendations to improve the channels for reporting safety concerns, the Safety Division developed and implemented an independent, confidential reporting system. The NASA Safety Reporting System (NSRS) is fully operational and serves as an alternate means for reporting safety concerns relative to the Shuttle program. Plans will be developed to increase the scope of the system to cover other NASA programs in the future.

The STS Safety Risk Assessment Ad Hoc Committee was established to conduct an independent safety review and assessment of the STS safety management structure. The committee released its report in August 1987. A plan to implement the committee's recommendations was developed and introduced to the Safety Directors at their first quarterly meeting in September 1987.

Rigorous institutional safety programs across the agency resulted in the lowest lost time frequency rate for civil service employees in over ten years. NASA exceeded the goal established by President Reagan for a three percent reduction in occupational injuries/illnesses each year over a period of five years by 22 percent. Field installations are to be congratulated on their effective safety awareness and awards programs. Efforts will continue to further reduce lost time illnesses and injuries among contractor employees.

Activities in the System Safety Program centered around STS FMEA/CIL and hazard analysis revalidation during FY 1987. Aerodynamic systems safety activities included participation in the X-Wing documentation audit and readiness reviews.

Operational safety assurance activities included the compilation and analysis of lessons learned from the Challenger accident and the development of plans for a Headquarters Expendable Launch Vehicles (ELV) Safety Review. The Aviation Safety Program continued to support the Interagency Aviation Operations Panel (IAOP).

During FY 1988 NASA will continue to strive for maximum safety awareness and excellence in all activities. The field installations and Headquarters plan to work together to maintain the emphasis on safety initiated after the Challenger mishap.

Robert H. Thompson

Robert H. Thompson
Director, Safety Division

FY 1987 SAFETY STATISTICS

Fatalities	0
Total injuries/illnesses	155
Lost time injuries/illnesses	75
Lost wages	$133,966
Chargeback billing	$5,026,436
Material losses	$8,492,300
Total losses	$13,652,702

NASA OCCUPATIONAL INJURY/ILLNESS RECORD

Injuries and illness are divided into two classes, lost time cases and no lost time cases. A lost time case is defined by OSHA as a nonfatal, traumatic injury that causes loss of time from work or disability beyond the day or shift when the injury occurred, or a nonfatal illness/disease that causes loss of time from work or disability at any time. A no lost time case is a nonfatal injury (traumatic) or illness/disease (nontraumatic) that does not meet the definition of a lost time case.

The NASA Headquarters Safety Division does not track all lost time cases as defined by OSHA but instead identifies those which are clearly work-related injuries for which preventive action or corrective action plans may be developed to prevent recurrence.

The number of lost time injuries/illnesses per 200,000 hours worked is a gross rate which expresses the number of lost time cases in relation to the number of hours worked. OSHA now uses a different formula to calculate incidence rates: the number of lost time cases per 100 employees. Several charts in this report reflect this formula.

Table 1 shows injury/illness statistics for all NASA field installations for FY 1987. The overall lost time rate of 0.35 is the lowest in more than ten years.

TABLE 1. NASA INJURY/ILLNESS DATA BY INSTALLATION - FY 1987

			TOTAL INJURY/ ILLNESS DATA			LOST TIME INJURY/ILLNESS DATA					PERFORMANCE VS GOAL FOR FY 87	
	NO. OF EMPLOYEES	HOURS WORKED IN K	NO. CASES	FREQ. RATE 1986	FREQ. RATE 1987	NO. CASES	NO. DAYS	FREQ. RATE 1986	FREQ. RATE 1987	SEVERITY RATE	CUM. RATE	TARGET RATE
ARC/DFRF	2,096	4,699	35	1.93	1.49	13	28	0.87	0.56	1.19	0.56	0.40
GSFC/WFF	3,647	6,683	17	0.83	0.51	11	74	0.27	0.33	2.21	0.33	0.30
HQ	1,580	2,768	27	1.15	1.95	3	77	0.51	0.22	5.56	0.22	0.40
JSC	3,740	6,103	11	0.96	0.36	8	140	0.43	0.26	4.59	0.26	0.30
KSC	2,187	4,639	12	0.31	0.51	6	65	0.09	0.26	2.80	0.26	0.30
LaRC	2,986	5,755	11	0.54	0.38	5	32	0.19	0.17	1.11	0.17	0.30
LeRC	2,764	5,118	26	1.67	1.02	22	217	0.93	0.86	8.48	0.86	0.50
MSFC	3,307	6,927	14	0.80	0.40	5	131	0.33	0.14	3.78	0.14	0.30
NSTL	146	299	2	0	1.34	2	11	0	1.34	7.36	1.34	0
NASA	22,453	42,991	155	--	0.72	75	775	--	0.35	3.60	0.35	0.40
LAST YEAR	23,301	39,907	196	0.98	--	86	929	0.43	--	4.66	0.43	0.30

1. Total injury/illness frequency rate = number of cases per 200,000 hours worked.
2. Lost time injury/illness frequency rate = number of lost workday cases per 200,000 hours worked.
3. Injury/illness severity rate = number of lost workdays per 200,000 hours worked.

Figure 1 illustrates the relative position of the NASA occupational injury/illness incidence rate compared to other Federal agencies having more than 15,000 employees in FY 1986 and FY 1987. Within the Federal Government NASA ranked second in both years. These statistics are based on the number of lost-time cases per 100 employees.

Figure 2 plots the NASA lost time injury/illness rates for the last 11 years against those of other Federal agencies and select private sector industries. NASA's rates have been consistently lower than those of the Federal Government and the private sector. The most recent statistics available from the Department of Labor for private sector industry are for FY 1986.

Figure 3 illustrates NASA's excellent overall illness/injury record as compared to all other Federal agencies, the private sector, private sector manufacturing industry, and the private sector aerospace industry over the last 11 years. The most recent statistics available from the Department of Labor are for FY 1986.

Figure 4 compares the lost time frequency rates at the NASA field installations to the overall NASA lost time frequency rate of 0.35. These statistics are based on the number of lost time cases per 200,000 hours worked.

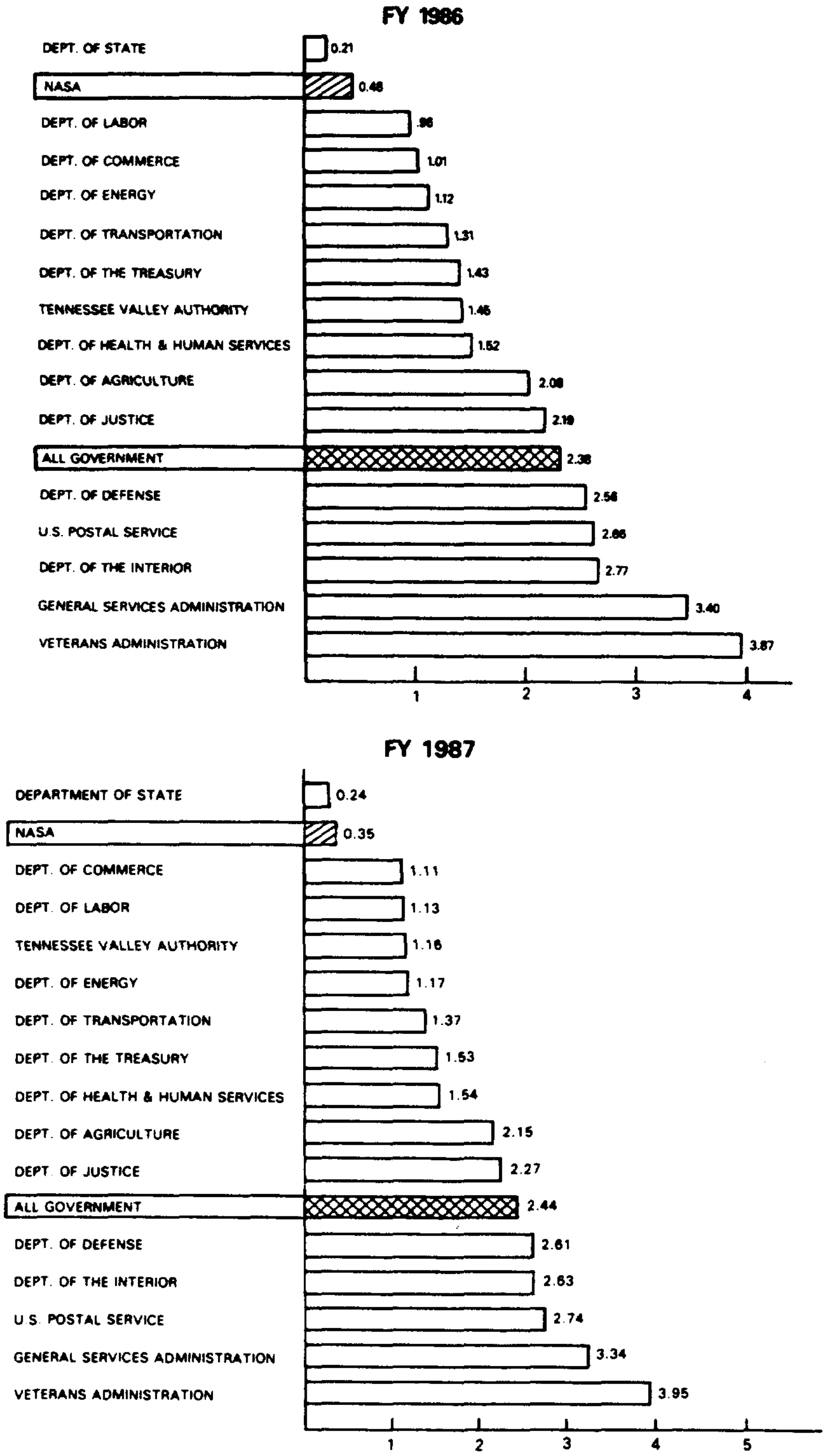
Figure 5 compares the number of NASA employees to the number of lost-time cases over the past 11 years. In FY 1987 there were 75 lost time cases among the 22,453 NASA employees.

Figure 6 plots the lost time frequency rate, the no lost time rate, and the total reportable rate per 200,000 hours worked. NASA experienced a decrease in these rates in FY 1987.

Table 2 shows the lost time rates for both NASA civil service and contractor employees by installation. The contractor lost time rate of 0.87 reflects a decrease from last year's rate.

Figure 7 compares the lost time frequency rates of NASA and contractor employees at each installation for the last two years.

LOST-TIME INJURY/ILLNESS RATES IN SELECT FEDERAL AGENCIES*



* HAVING MORE THAN 15,000 EMPLOYEES
- OSHA NO LONGER CALCULATES RATES BASED ON 200,000 HOURS WORKED

Figure 1

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LOST-TIME OCCUPATIONAL INJURY/ILLNESS RATES:

PRIVATE SECTORS-ALL FEDERAL AGENCIES-NASA

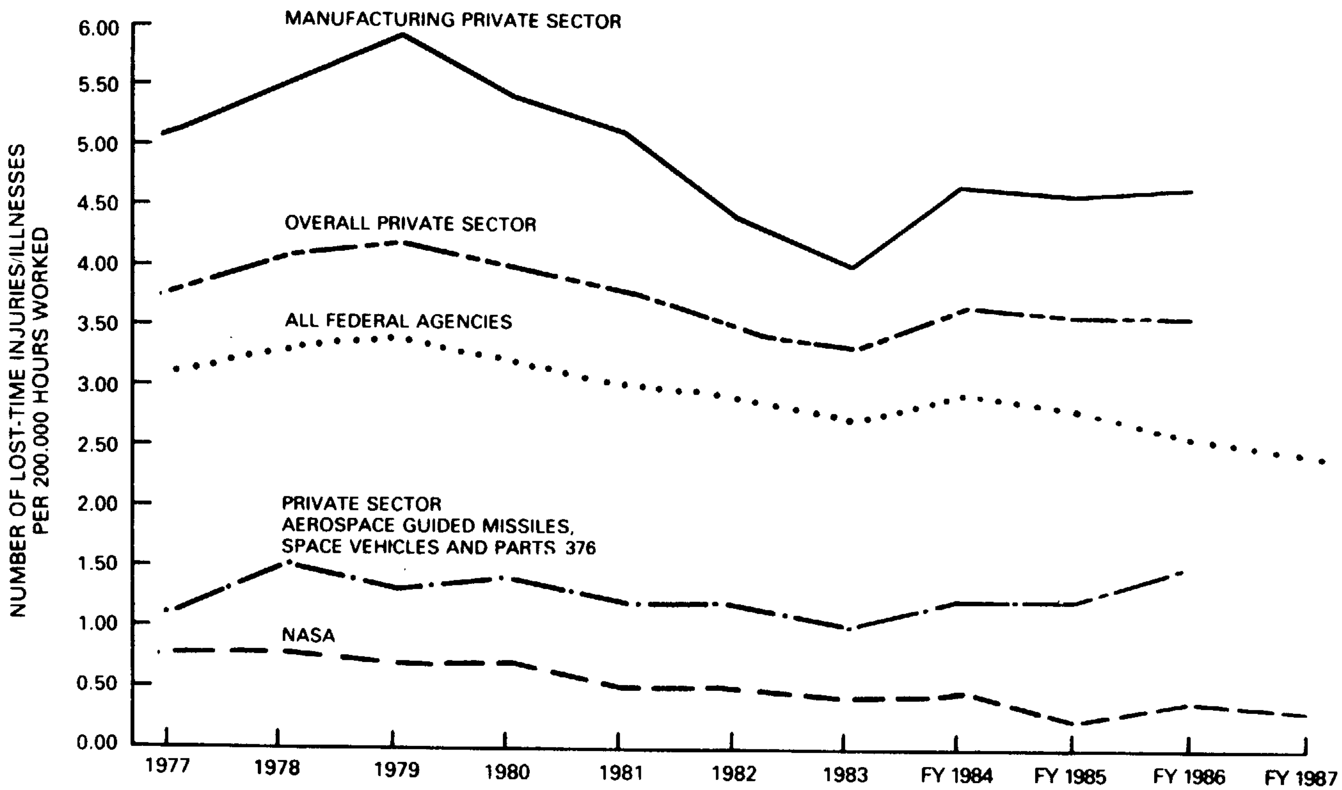

Figure 2

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TOTAL OCCUPATIONAL INJURY/ILLNESS RATES:

PRIVATE SECTORS-ALL FEDERAL AGENCIES-NASA

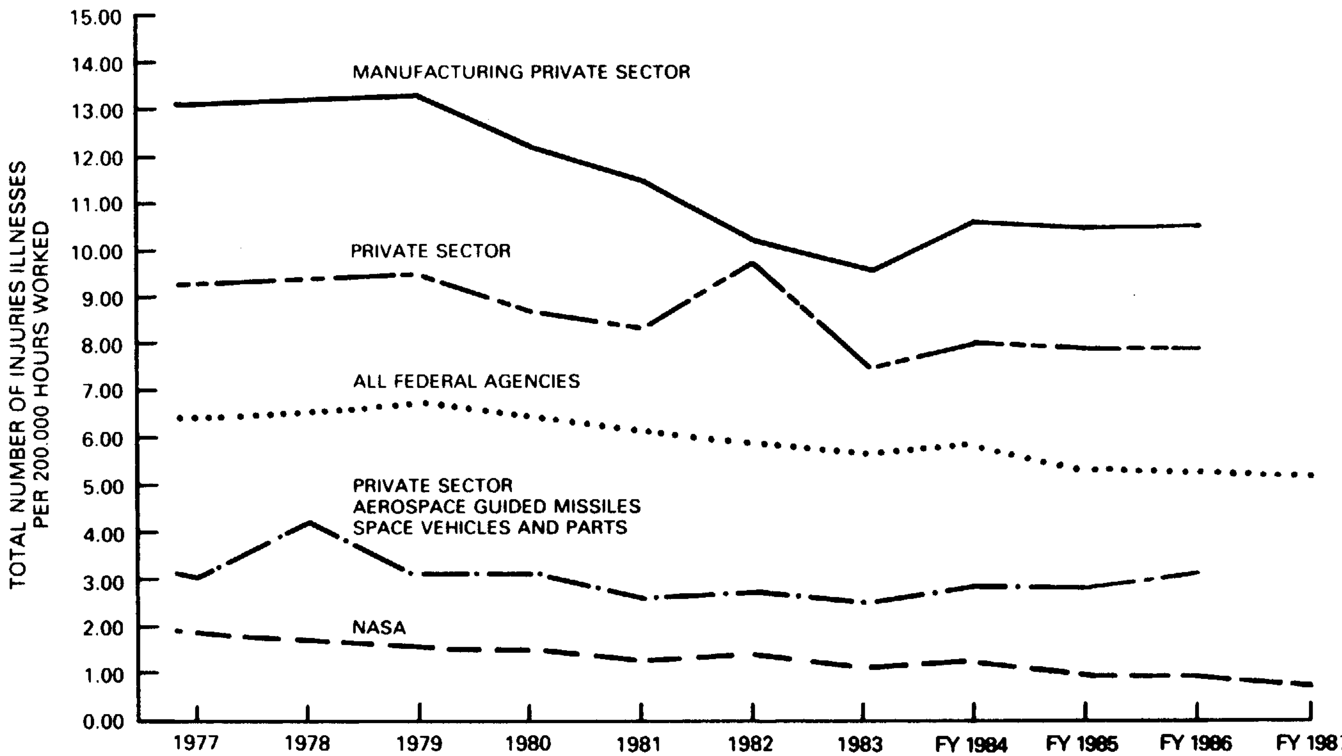

Figure 3

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LOST TIME RATES
BY CENTER
1977-1987

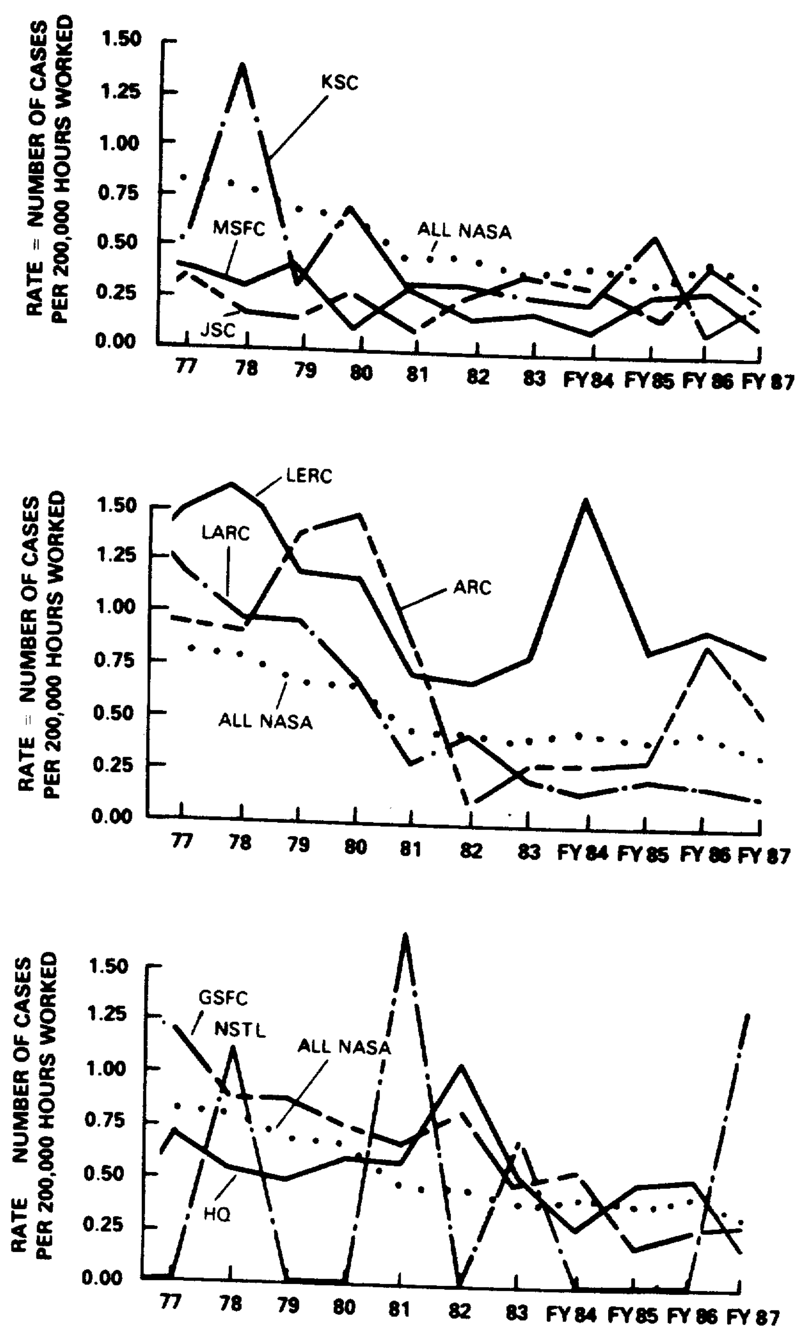

Figure 4

NUMBER OF NASA EMPLOYEES AND LOST TIME CASES VS. TIME 1977-1987

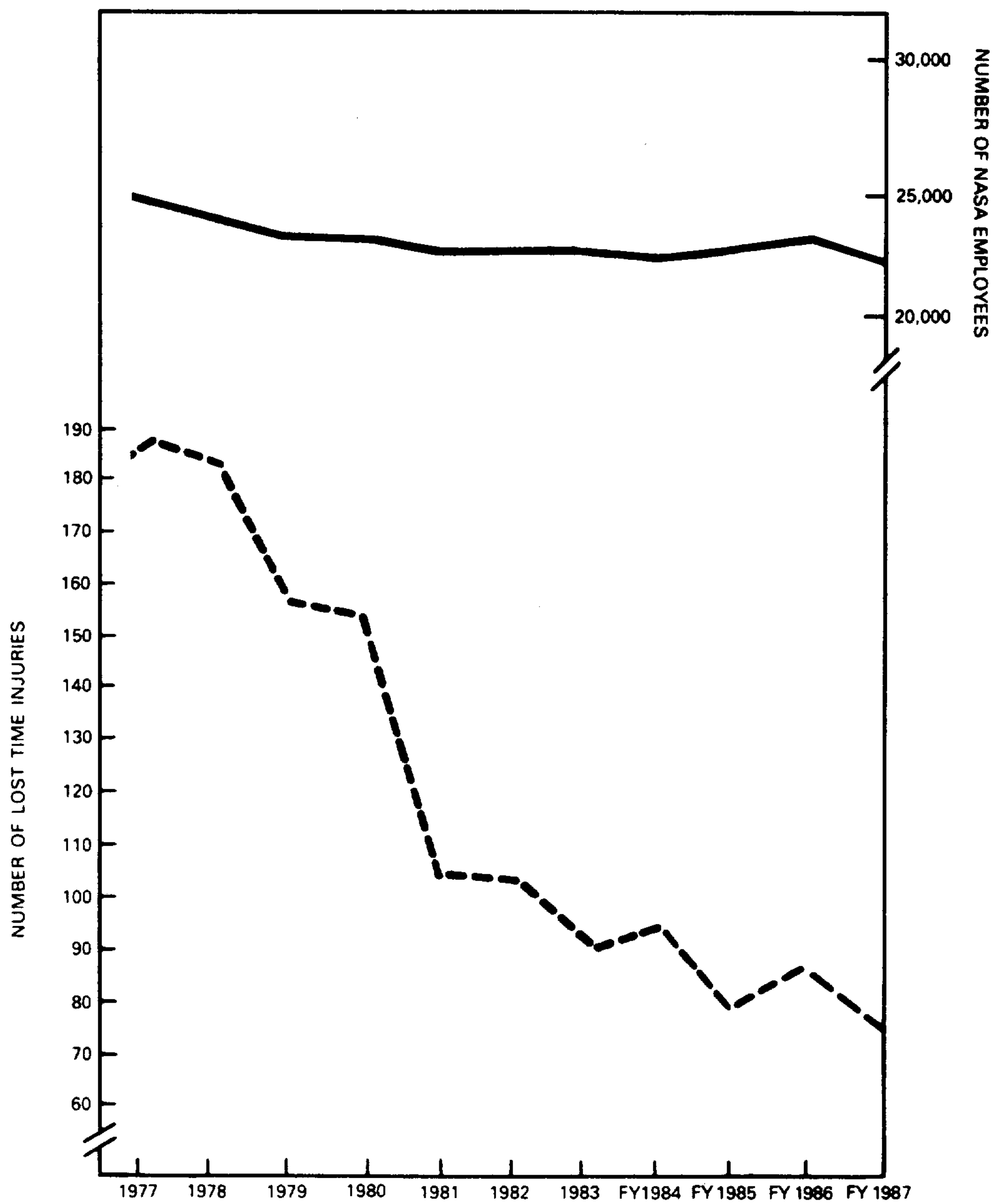

Figure 5

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NASA OCCUPATIONAL INJURY/ILLNESS* RATES**
1977-1987

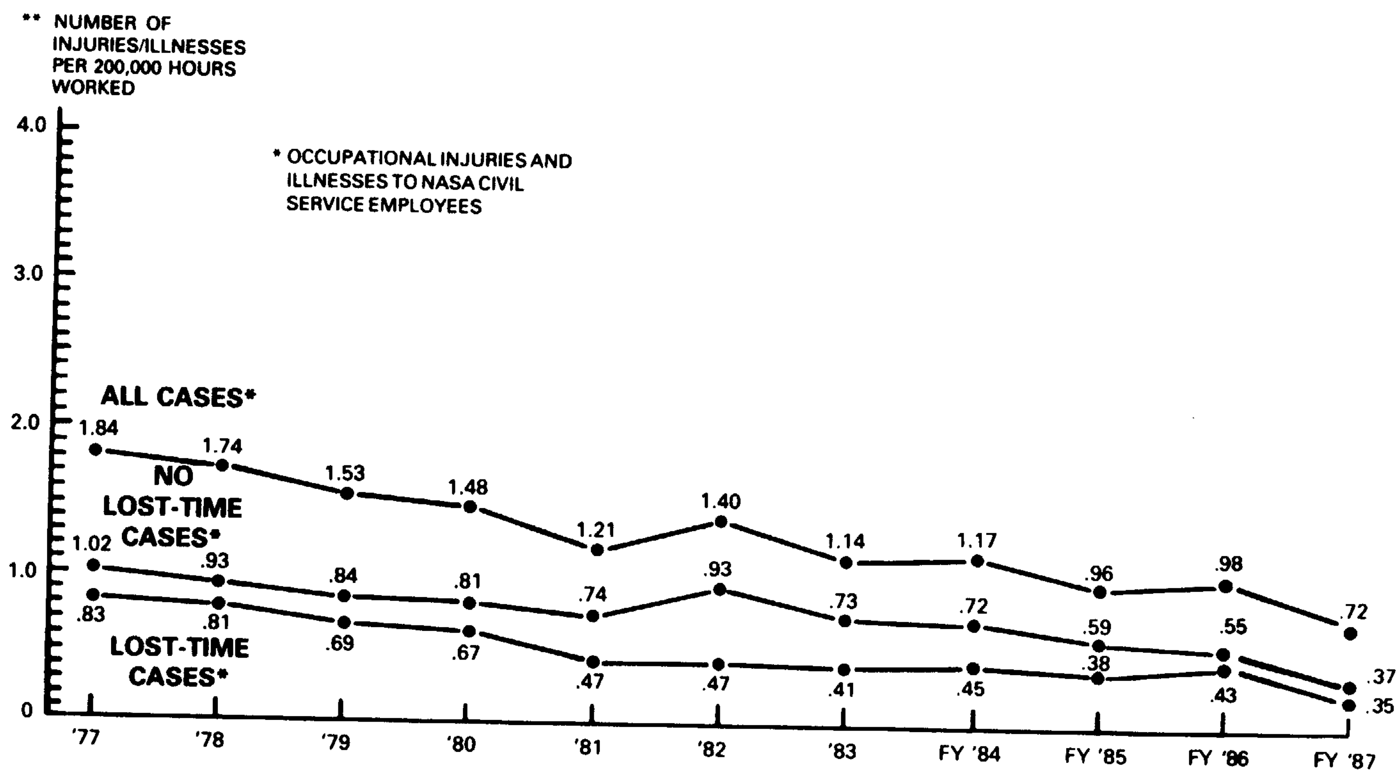

Figure 6

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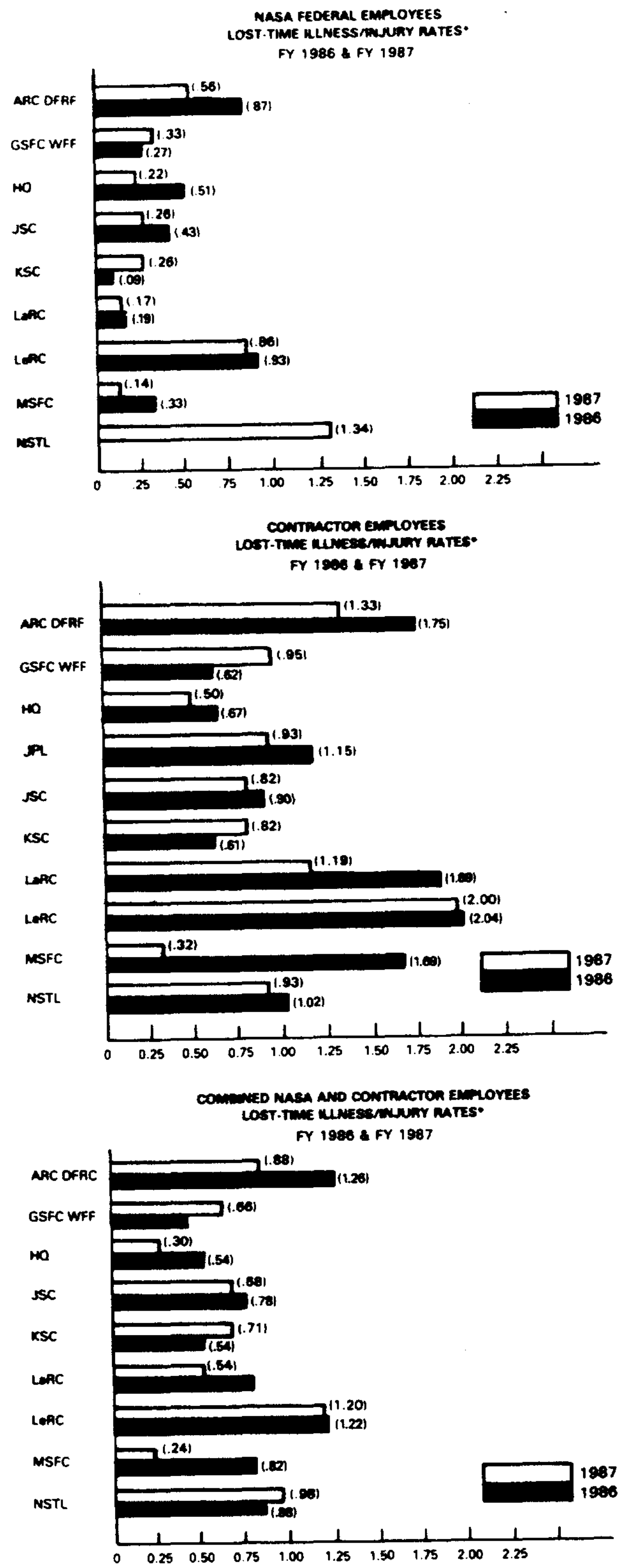

*RATE NUMBER OF CASES PER 200,000 HOURS WORKED

Figure 7

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9-19-88

TABLE 2. NASA COMBINED INJURY/ILLNESS DATA BY INSTALLATION - FY 1987
CIVIL SERVICE AND CONTRACTOR EMPLOYEES

	HOURS (K) CIV. SERV. EMPLOYEES	NO. L-T CASES	FREQ. RATE	HOURS (K) CONTRACTOR EMPLOYEES	NO. L-T CASES	FREQ. RATE	HOURS (K) COMBINED TOTAL	TOTAL L-T CASES	COMBIMED FREQ. RATE
ARC/DFRF	4,699	13	0.56	3,464	23	1.33	8,163	36	0.88
GSFC/WFF	6,683	11	0.33	7,767	37	0.95	14,450	48	0.66
HQ	2,768	3	0.22	1,236	3	0.49	4,004	6	0.30
JPL	---	-	--	11,800	55	0.93	11,800	55	0.93
JSC	6,103	8	0.26	18,437	76	0.82	24,540	84	0.68
KSC	4,639	6	0.26	20,013	82	0.82	24,651	88	0.71
LaRC	5,755	5	0.17	3,185	19	1.19	8,940	24	0.54
LeRC	5,118	22	0.86	2,197	22	2.00	7,315	44	1.20
MSFC	6,927	5	0.14	7,425	12	0.32	14,352	17	0.24
NSTL	299	2	1.34	2,158	10	0.93	2,457	12	0.98
NASA	42,991	75	0.35	77,682	339	0.87	120,672	414	0.69
LAST YEAR	39,907	86	0.43	76,645	366	0.96	116,552	452	0.78

Lost time injury/illness frequency rate = number of lost workday cases per 200,000 hours worked.

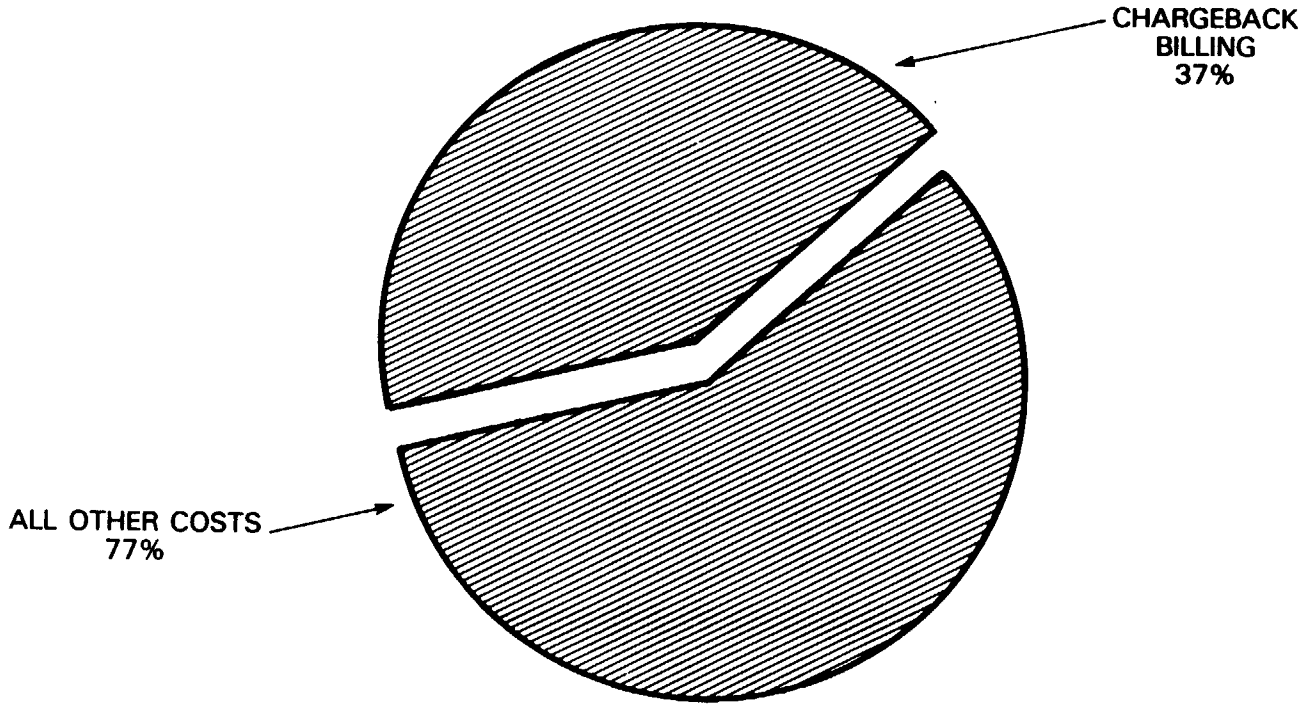
CHARGEBACK BILLING

Chargeback is defined by OSHA as a system under which the U.S. Department of Labor pays compensation and medical costs attributed to injuries which occurred after December 1, 1960 and then bills the agency which employed the individual who received compensation or benefits. In any given year, most of the chargeback billing is a result of illnesses and injuries which occurred in previous years. Only 2%, or $100,855, of the chargeback billing costs paid in FY 1987 was for injuries which actually occurred during that year.

Figure 8 illustrates the relationship between chargeback billing and all other mishap- and injury-related costs. These include lost wages (continuation of pay) as well as aviation, automobile, fire, and other reportable mishaps. Of the $13.7 million total loss for FY 1987, $5 million, or 37%, was paid out in chargeback billing costs. In past years, chargeback billing costs have exceeded those associated with material losses and lost wages combined. In FY 1987 chargeback billing costs represented a smaller percentage of total losses from mishaps and injuries.

Figure 9 illustrates the trend of chargeback billing in the Federal Government and in NASA for the last 11 years. While the Federal Government's chargeback billing costs continue to increase (27% in FY 1987), NASA's appear to have stabilized at around $5 million annually.

COST OF FY 1987 NASA MISHAPS/INJURIES
*TOTAL LOSS = $13,652,702



* DOES NOT INCLUDE
COST OF MISSION FAILURES
AND TEST OPERATIONS LOSSES

Figure 8

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TIME HISTORY OF (OWCP) CHARGEBACK BILLINGS
COSTS FOR ALL FEDERAL GOVERNMENT AGENCIES AND NASA
(IN MILLIONS OF DOLLARS)

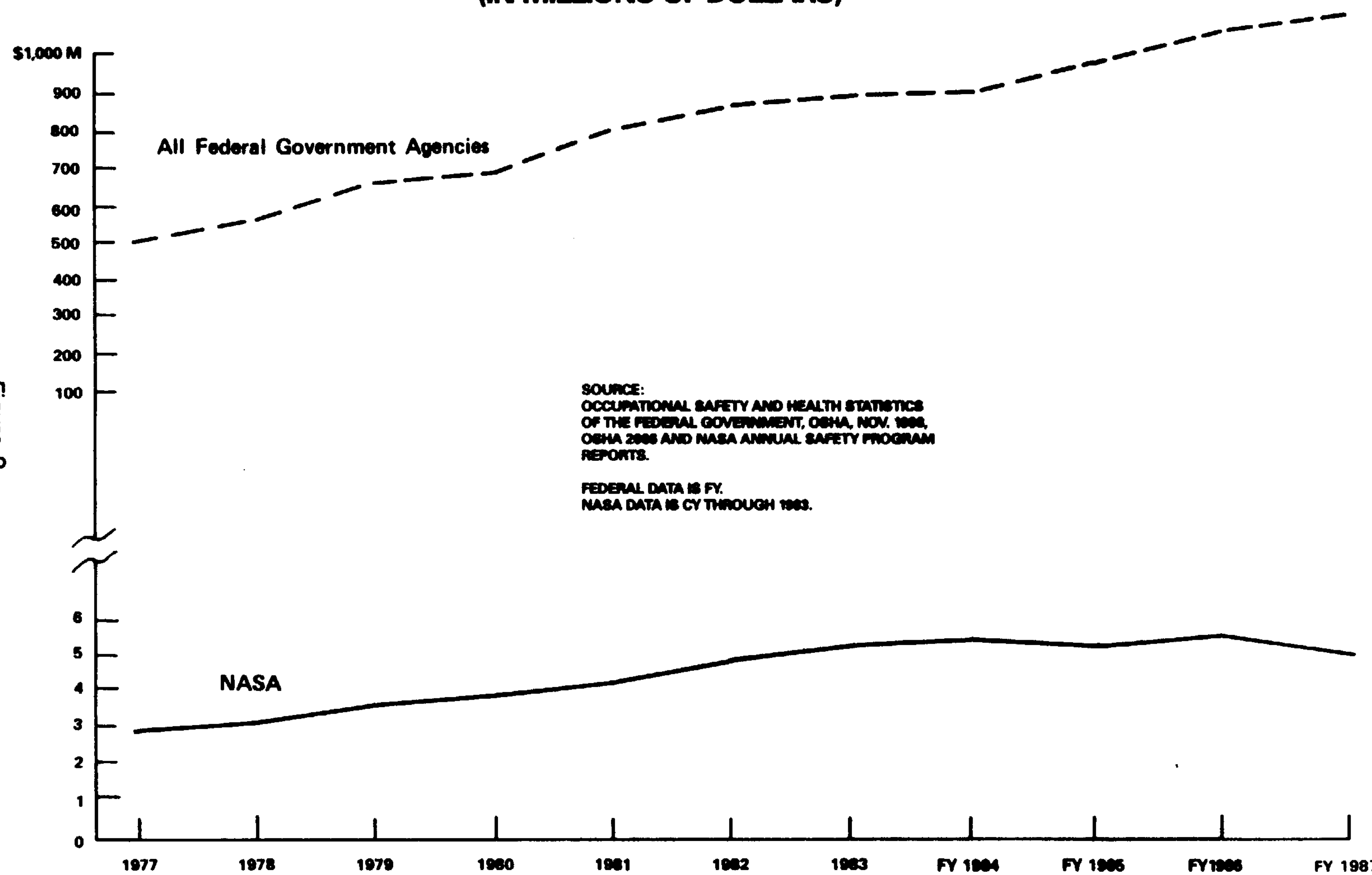

Figure 9

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9-19-88

MATERIAL LOSSES

Table 3 lists the statistics for NASA material losses during FY 1986. Rescheduling and equipment replacement costs from major mission failures such as the AtlasCentaur-67 are not included in these statistics. Summaries of major mishaps which occurred in FY 1987 begin on page 32.

Figure 10 illustrates the total cost of material losses over the last 11 years.

Figure 11 illustrates the cost of aircraft losses over the last 11 years. The loss of the Convair 990 in FY 1985 represents the most costly aviation mishap in recent years. This year's single aviation mishap resulted in severe damage to a T-38 which was struck by lightning while preparing to land.

NASA's FY 1987 government automobile accident frequency rate increased for the second consecutive year to 1.97 accidents per million miles driven. This rate, however, is significantly lower that the goal of 5.0 established by NASA in 1980. Figures 12 and 13 show the frequency rates and costs of automobile accidents for the last 11 years.

NASA experienced eight minor fires resulting in $173,000 in damage in FY 1987. NASA's excellent record in fire experience as illustrated in Figure 14 is a reflection of aggressive fire prevention programs throughout the agency.

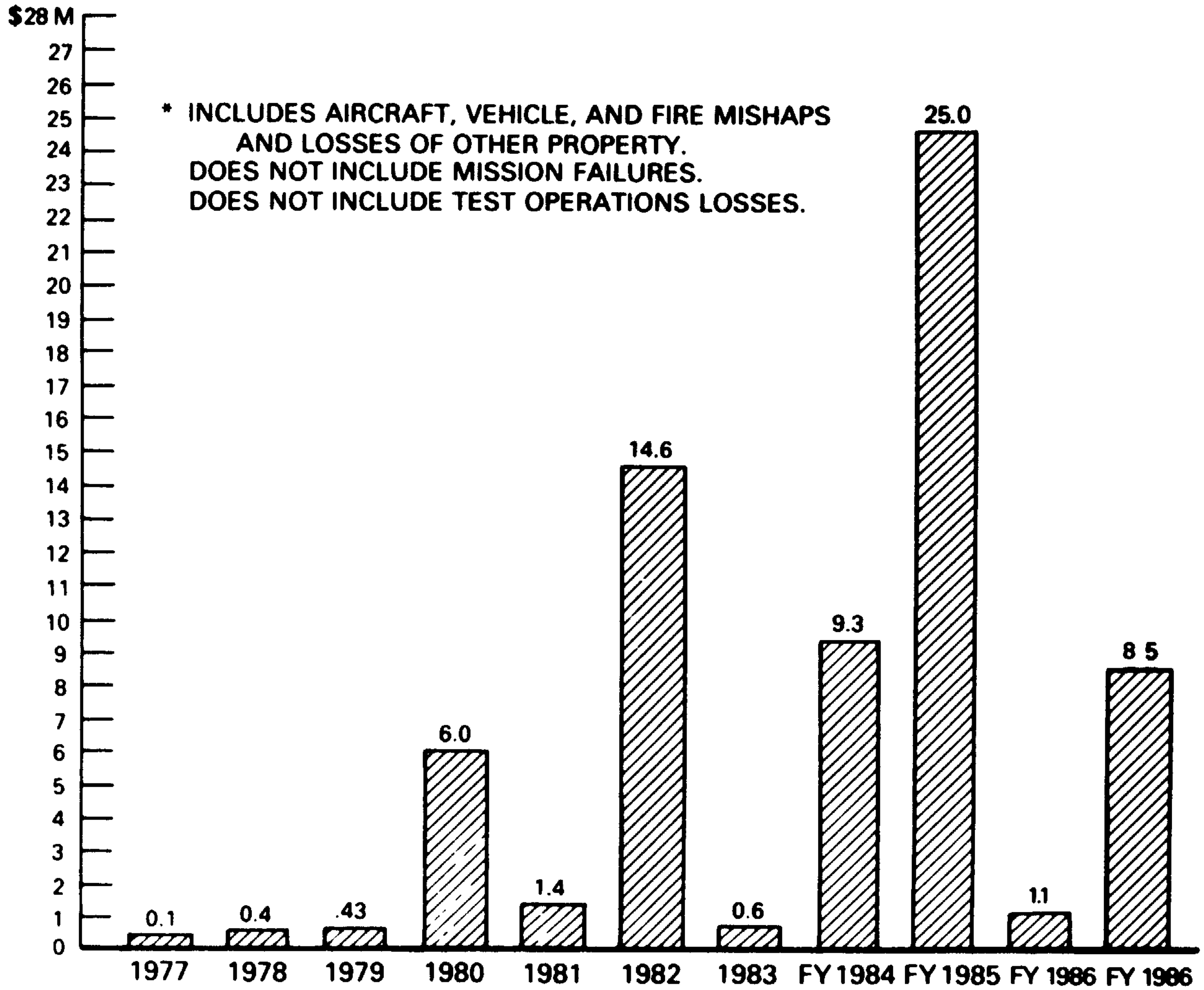
TABLE 3. NASA MATERIAL LOSSES BY INSTALLATION - FY 1987
(COSTS ARE IN THOUSANDS OF DOLLARS)

	AUTO MISHAPS				AIRCRAFT MISHAPS		FIRE LOSSES		OTHER MISHAPS		TOTALS		
	GOV		POV								TORT	NO.	
	NO.	COST	NO.	COST	NO.	COST	NO.	COST	NO.	COST	COSTS	MISHAPS	COST
ARC/DFRF	1	3.0	0	0	0	0	0	0	1	125	11	2	139
GSFC/WFF	3	4.4	1	1.0	0	0	0	0	1	45	1	5	51.4
HQ	2	1.6	8	4.3	0	0	0	0	2	6.8	8.7	13	21.4
JPL	0	0	0	0	0	0	0	0	1	10	0	1	10
JSC	0	0	0	0	1	275	1	5	6	454.2	0	8	734.2
KSC	16	19.5	0	0	0	0	5	8.7	29	5,110	5.7	50	5,143.9
LaRC	0	0	0	0	0	0	1	.6	8	45.0	1.0	9	46.6
LeRC	0	0	0	0	0	0	1	3.0	1	9.6	6.5	2	19.1
MSFC	5	5.5	0	0	0	0	0	0	18	2,312.3	8.9	23	2,326.7
NSTL	0	0	0	0	0	0	0	0	0	0	0	0	0
NASA	27	34	9	5.3	1	275	8	17.3	67	8,117.9	42.8	113	8,492.3
LAST YEAR	34	61.2	1	.9	0	0	0	0	36	1,057.2	9.1	71	1,128.4

1. Auto Mishaps for GOVs include GSA leased vehicles and for POVs, rental cars.
2. Tort Costs are for claims paid in this reporting period.

Figure 10
19

NASA MATERIAL LOSSES DUE TO MISHAPS*
(IN MILLIONS OF DOLLARS)
1977-1987



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NASA AIRCRAFT LOSSES
(IN MILLIONS OF DOLLARS)
1977-1987

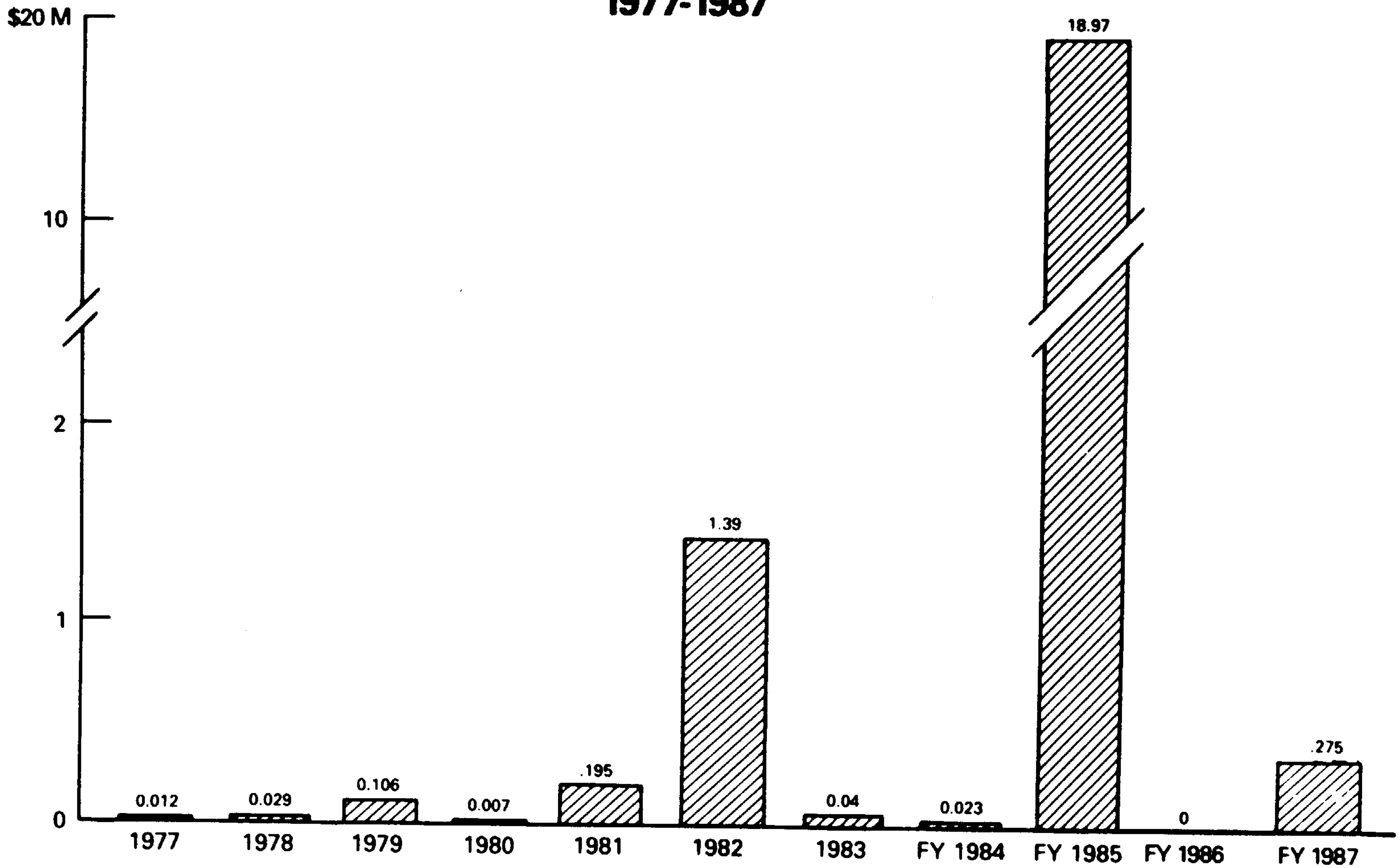

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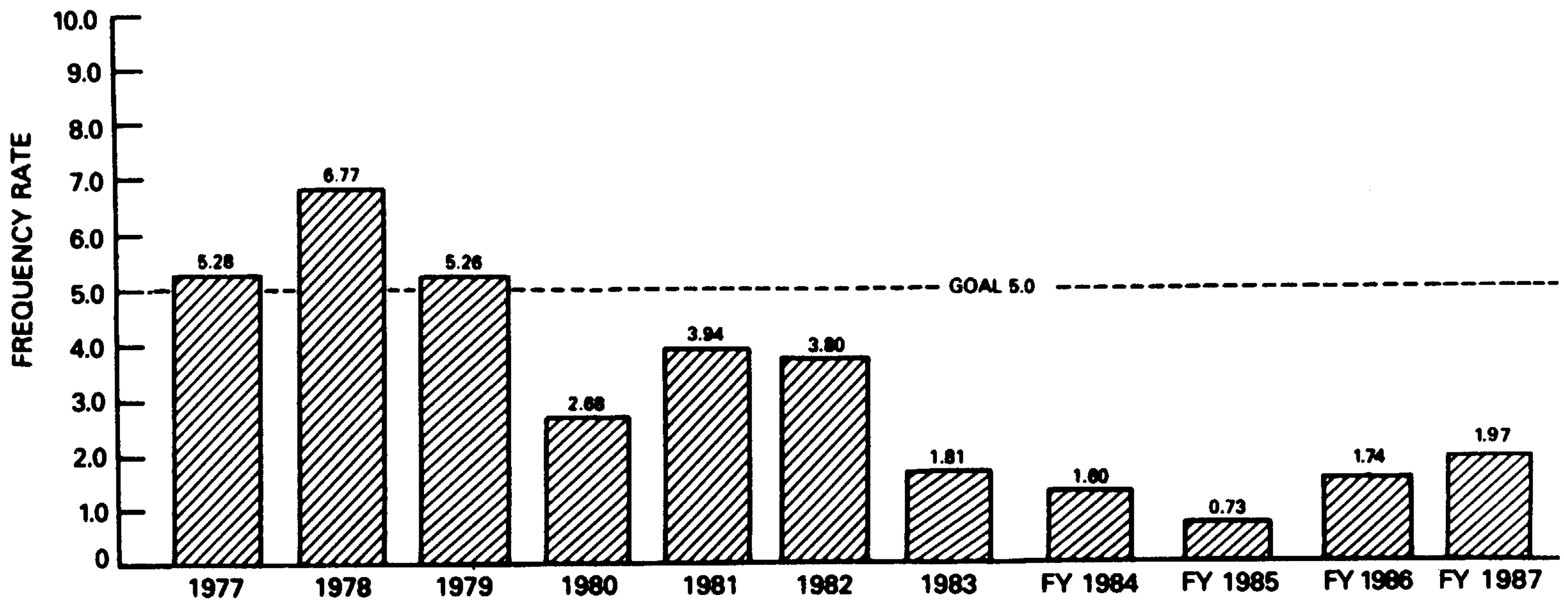
Figure 11

NASA GOVERNMENT MOTOR VEHICLE ACCIDENT FREQUENCY RATES 1977-1987



FREQUENCY RATE IS THE NUMBER OF MOTOR VEHICLE ACCIDENTS PER MILLION MILES DRIVEN.

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Figure 12

NASA MOTOR VEHICLE ACCIDENT LOSSES
GOV AND POV
(IN THOUSANDS OF DOLLARS)
1977-1987

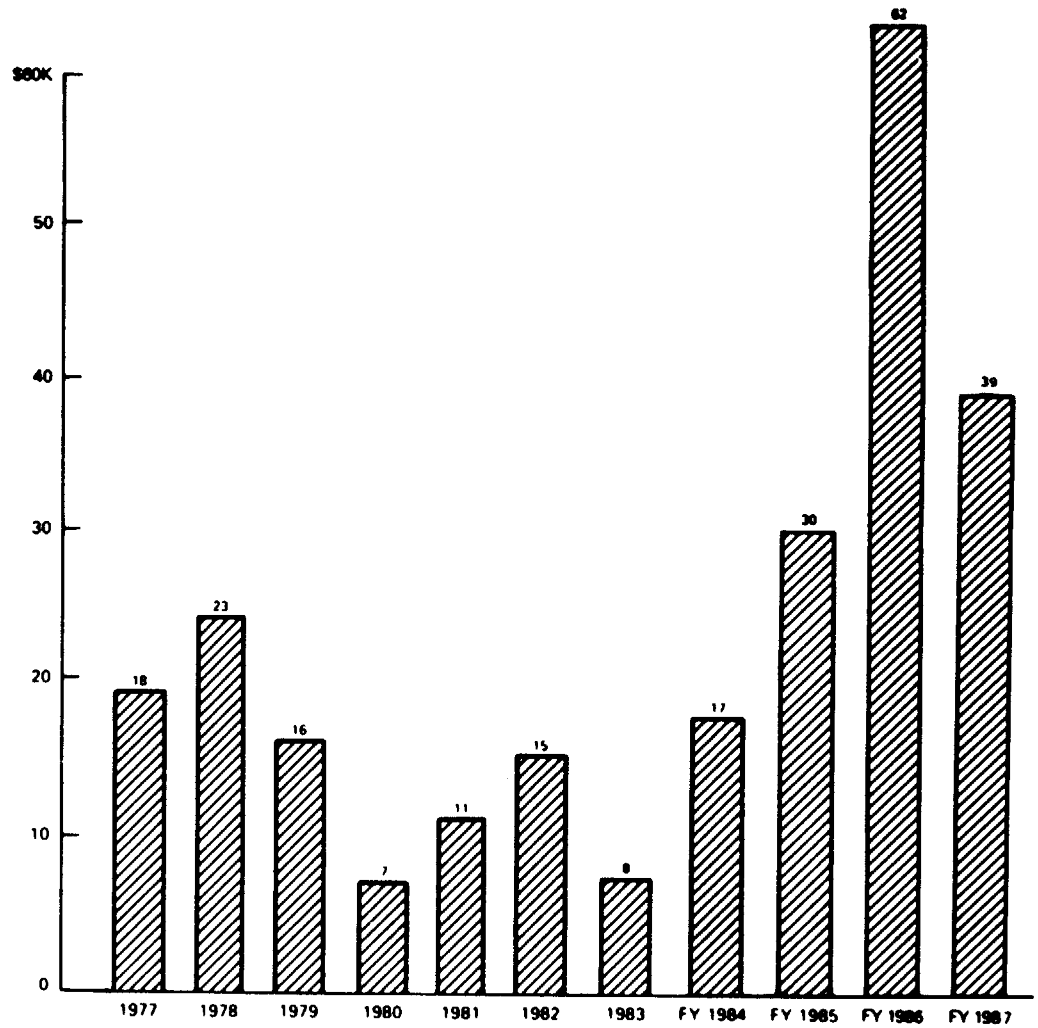

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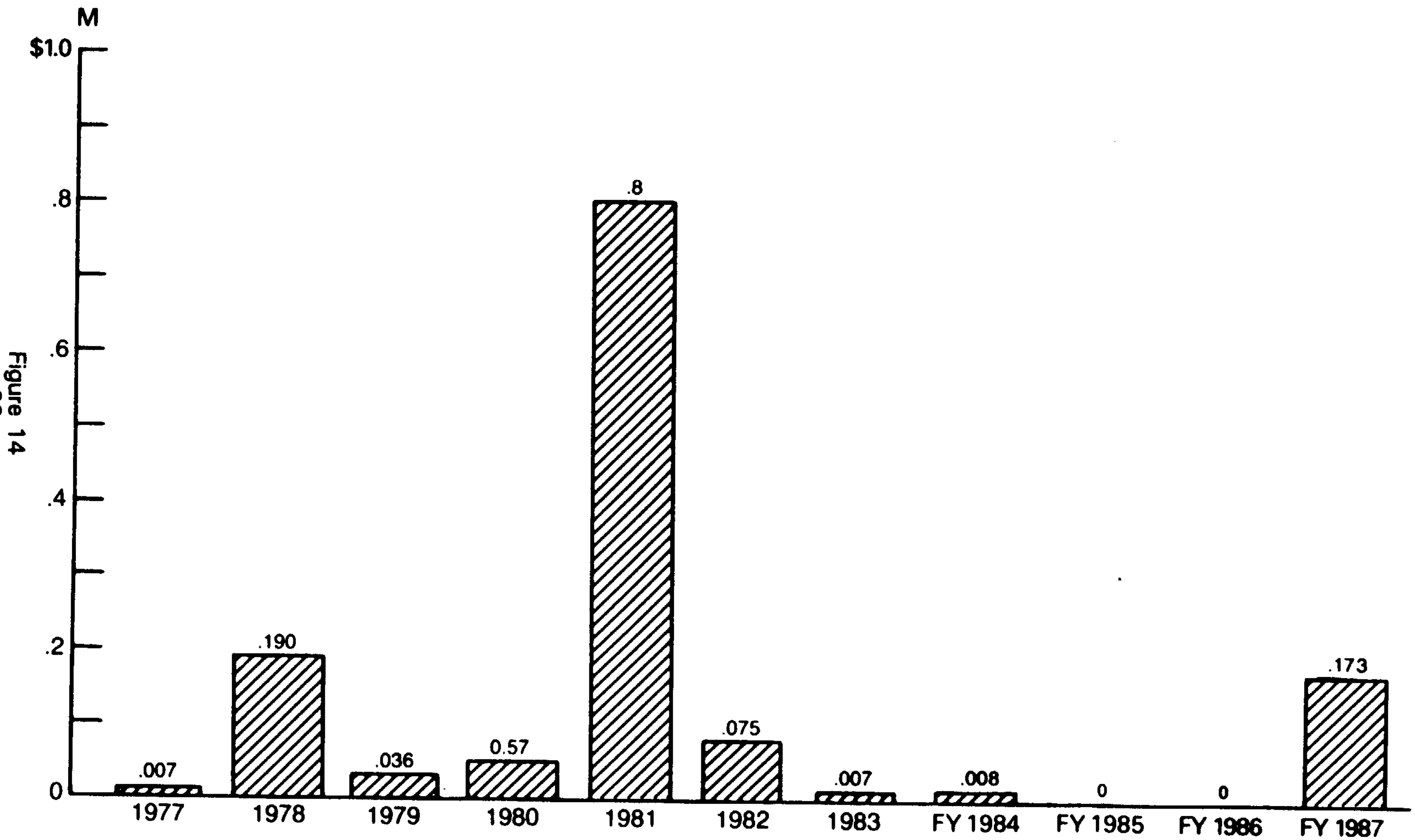
Figure 13
22

NASA FIRE LOSSES
(IN MILLIONS OF DOLLARS)
1977-1987



DOES NOT INCLUDE TEST OPERATIONS OR MISSION FAILURES

Figure 14
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NASA HQ QS88-638 (1)
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NASA MISHAP DEFINITIONS

TYPE A MISHAP: A mishap causing death, damage to equipment or property equal to or exceeding $500,000, destruction of an aircraft, or destruction of space hardware. NASA Type A mishaps are investigated by a board appointed by the appropriate program or institutional Associate Administrator.

TYPE B MISHAP: A mishap resulting in permanent disability to one or more persons, hospitalization of five or more persons, or damage to equipment or property costing from $250,000 to less than $500,000. NASA Type B mishaps are investigated by a board appointed by the director of the field installation.

TYPE C MISHAP: A mishap resulting in damage to equipment or property costing from $25,000 to less than $250,000, or causing occupational injury or illness which results in a lost workday (or workdays) or restricted duty. NASA Type C mishaps are analyzed locally by committees or individuals unless circumstances dictate a more formal investigation.

MISSION FAILURE: Any event of such a serious nature that it prevents accomplishment of the majority of the primary mission objectives. Mission failures are usually investigated by a formal board.

TEST FAILURE: An unexpected event which jeopardizes a test, prevents accomplishment of major test objectives, causes premature test termination, or destroys test hardware, test stands, or monitoring equipment. Test failures generally result in monetary losses of $25,000 or more, have significant impact on a particular program, or have political or public visibility. A program may call for the use of low cost models and other test items which are specifically designed to meet certain test conditions where damage is likely to occur. When these are damaged or destroyed, circumstances will determine if a test has in fact occurred or if the damage was a likely result of the test. Test failures are investigated or analyzed as determined by program personnel. (When a part or assembly fails without causing a significant monetary loss or program delay, a test failure, according to this definition, has not occurred.)

INCIDENT: An unplanned occurrence which results in injuries to personnel of less severity than those in a Type C mishap or which results in property loss or damage in excess of $500 but less that $25,000. A close call that could generate wide-spread interest may be included in this category.

CLOSE CALL: An unplanned occurrence in which there is no injury, property damage, or interruption of work, but which has the potential for any of these.

COSTS: Direct costs of repair, retest, delays, replacement, or recovery of NASA property including manhours, material, and contract costs but excluding indirect costs of cleanup, investigation, injury, and normal operational delay.

NASA MISHAP: Any unplanned event or anomaly that may be classified as a Type A, B, or C mishap, incident, or mission or test failure that involves NASA personnel, equipment, or facilities.

NASA CONTRACTOR MISHAP: Any unplanned event or anomaly that may be classified as a Type A, B, or C mishap, incident, or mission or test failure that involves NASA contractor personnel or equipment in support of operations at NASA. These are normally investigated by the contractor and reviewed by NASA, or depending upon the circumstances, investigated separately by NASA when directed by a NASA official with board appointment authority.

The significant mishaps shown in Tables 4 and 5 are those reported by the NASA field installations as having significance beyond the minor dollar losses or injury incident categories. These mishaps provide "lessons learned" for all NASA accident prevention programs.

Figure 15 presents an 11-year overview of NASA Type A, Type B, and Type C mishaps. The Type B and C mishaps reported here are those which resulted in property damage of an amount greater than $25,000. Type B and C personal injuries are reflected in Tables 1 and 2. The dollar limits for each category have escalated over the years due to inflation.

Figure 16 presents an 11-year history of NASA's total losses from chargeback billing costs, lost wages and material losses due to mishaps.

Table 6 compares the number of major mishaps experienced by the individual field installations, the lost-time rate of civil service and contractor employees, and the cost of material losses for the fiscal year against the installations' goals and the previous year's totals. In addition, the status of the pressure vessel recertification effort, begun in 1981 and scheduled for completion in 1987, is also reported on this Table.

TABLE 4. FATALITIES

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
NASA EMPLOYEES	2	0	1	0	4	1	0	0	0	3	0
CONTRACTOR EMPLOYEES	3	1	0	0	5	1	0	1	1	6	1
OTHERS	1	0	0	0	0	0	0	0	0	3	0
TOTALS	6	1	1	0	9	2	0	1	1	12	1

TABLE 5. NASA TYPE A/B/C MISHAPS BY FIELD INSTALLATION

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
ARC/DFRF	0/0	1/3	0/6	0/0	2/3	2/3	1/0/2	1/0/5	1/0/1	0/0/0	0/0/1
GSFC/WFF	1/4	0/0	0/1	1/1	0/3	1/0	1/0/1	0/0/0	0/0/1	1/0/0	0/0/1
HQ	0/1	0/0	0/0	0/0	0/0	0/0	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0
JPL										0/0/0	0/0/0
JSC	2/1	0/0	0/2	1/0	2/0	0/1	0/0/0	0/0/0	0/0/0	1/0/0	1/1/0
KSC	2/1	0/0	0/0	0/1	5/3	1/2	0/0/1	0/0/0	0/0/6	1/0/2	1/0/0
LaRC	0/0	0/1	0/0	0/0	3/4	1/0	0/0/0	0/0/0	1/0/0	0/0/2	0/0/0
LeRC	0/0	0/0	1/1	0/0	0/2	0/0	0/0/2	0/0/0	1/0/1	0/0/0	1/0/0
MSFC	1/0	0/0	0/0	2/1	1/0	4/2	0/1/2	2/0/0	0/0/0	0/0/0	2/0/3
NSTL	1/0	0/0	0/0	0/0	1/1	1/0	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0
TOTALS	7/7	1/5	1/10	4/3	14/14	10/8	2/1/8	3/0/5	3/0/9	3/0/4	5/1/5

1. Type "C" was first defined in 1983 and partially replaced the previously defined Type "B" mishap.
2. Types "B" and "C" individual injuries are not shown on this table. See Table 1.

NASA TYPE 'A', 'B', AND 'C' MISHAPS
1977-1987

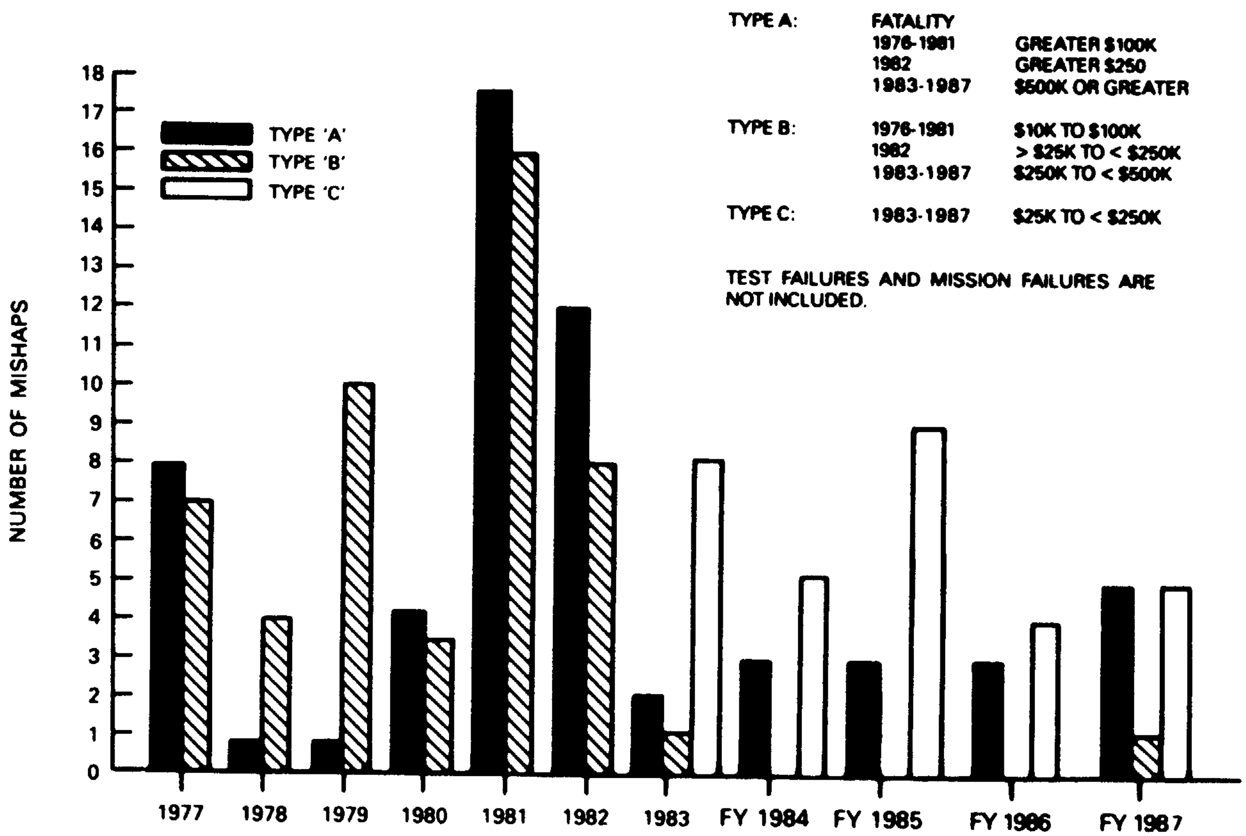

Figure 15

NASA HQ QS88-643 (1)
9-19-88

TOTAL COSTS TO NASA DUE TO MISHAPS*
(IN MILLIONS OF DOLLARS)
1977-1987

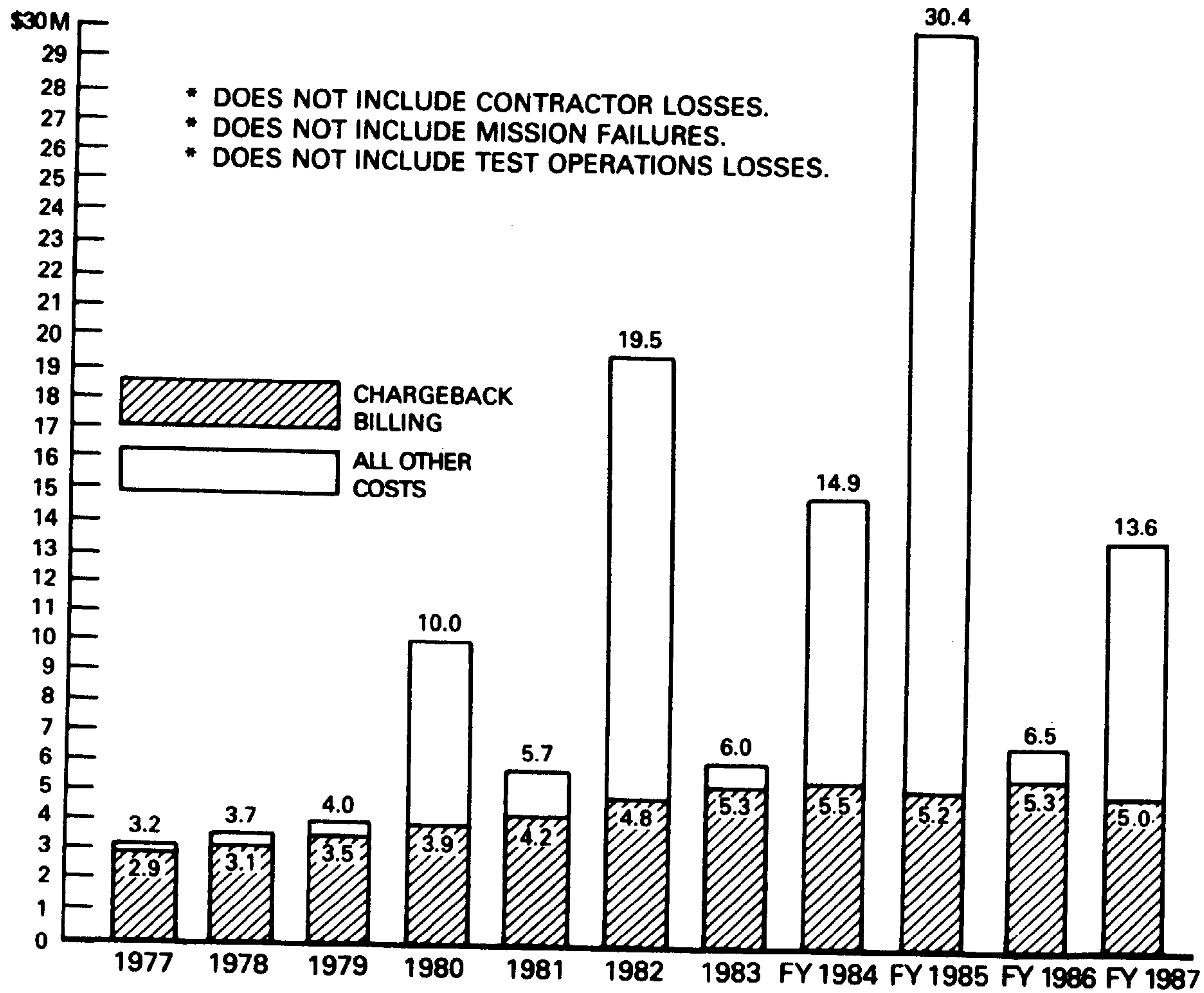

Figure 16

NASA HQ QS88-635 (1)
9-19-88

TABLE 6. GOAL STATUS FOR FY 1987

	TYPE A & B MISHAPS			TYPE C MISHAPS			NASA EMPLOYEE L-T RATE			CONTRACTOR EMPLOYEE L-T RATE			MONETARY LOSSES ($K)			PRESSURE VESSEL RECERTIFICATION (% complete)		
	1986	GOAL 1987	STATUS	1986	GOAL 1987	STATUS	1986	GOAL 1987	STATUS	1986	GOAL 1987	STATUS	1986	GOAL 1987	STATUS	1986	GOAL 1987	STATUS
ARC	0	0	0	0	1	1	.87	.40	.56	1.75	1.50	1.33	1.3	50	139	31	100	37
GSFC	0	0	0	0	0	1	.27	.30	.33	.62	.45	.95	11.7	70	51.4	WFF 40 NSBF 14	100 100	93 100
HQ	0	0	0	0	0	0	.51	.40	.22	.67	.40	.49	2.0	2	21.4	—	—	
JPL	0	0	0	0	0	0	—	—	—	1.15	—	.93	0	-	10	100	100	—
JSC	1	0	2	0	1	0	.43	.30	.26	.90	.90	.82	6.7	3	734.2	WSTF 100 DWPD 30	100 100	— 30
KSC	1	1	1	2	1	0	.09	.30	.26	.61	.70	.82	764.0	500	5,143.9	7	100	71
LaRC	0	0	0	2	0	0	.19	.30	.17	1.89	1.50	1.19	335.1	250	46.6	53	100	62
LeRC	0	0	1	0	0	0	.93	.50	.86	2.04	1.50	2.00	.6	50	19.1	84	100	94
MSFC	0	0	2	0	1	3	.33	.30	.14	1.69	1.00	.32	6.9	10	2,326.7	100	100	—
NSTL	0	0	0	0	0	0	0	0	1.34	1.02	.80	.93	0	25	0	100	100	—
NASA	2	1	6	4	4	5	.43	.40	.35	.96	.85	.87	1,128.4	1,000	8,492.3		100	

1. Goal for Type A mishaps is always zero. Mishap goals are for Types B and C property/equipment damage.

2. Contractor fatalities and mission and test failures are not considered in determination of goals.

MAJOR MISHAPS in FY 1987

NASA 914, T-38A JET TRAINER LIGHTNING STRIKE

On February 24, 1987, at 12:23 PST, a T-38A jet trainer, NASA 914, was struck by lightning while approaching the Los Alamitos Army Aviation Facility in California. The airplane landed in flames but safely at Los Alamitos with no injury to the crew members. The aircraft sustained extensive fire damage to the center fuselage section. The damage was initially estimated at $1.2M but later reduced to $275,000.

An initial investigation board was formed by the Director of the Johnson Space Center on February 25, 1987. On February 27, the Associate Administrator for Space Flight formed an inter-center board of investigation.

The board concluded that the lightning strike resulted in an in-flight explosion with subsequent fire. The most probable cause of the fire was the ignition of the JP-4 fuel/air mixture in the vent tube.

The board made 12 recommendations which included the institution of a lightning safety survey of all NASA administrative and training aircraft; the institution of a NASA-wide lightning strike reporting system; and the elimination of potential lightning ignition sources in the T-38A fuel system. The board requested that the NOAA-National Weather Service compile and disseminate significant lightning/aircraft lightning strike information in a timely manner through AIRMETS and SIGMETS.

SRM SEGMENT TRANSPORTATION MISHAP

On April 29, 1987, at approximately 4:45 p.m. PDT, a transport carrier loaded with an SRM case segment and a stiffener ring struck an overpass and completely destroyed the SRM segment. The driver and his escort deviated from the approved route when they realized that they would not reach their destination before the 5:00 p.m. California curfew for oversized loads. The drivers did not appear to have realized that the alternate route did not have the necessary 16-foot clearance for their load. The SRM segment, which was behind the stiffener ring on the trailer, struck the overpass and deflected to the left of the trailer, coming to rest horizontally in the dividing median against the overpass stanchion. The segment, with an estimated value of $600,000, was declared a total loss.

The investigation board found that Morton-Thiokol, Inc. (MTI), assumed very little control over the selection of drivers employed by the contract carriers. There was no training, certification or briefing of the drivers, nor was there adequate emergency/contingency planning. The board recommended that the contract for transporting SRM segments include the requirement for certification of truck and escort drivers. Also, both the tractor-trailer drivers and the escort drivers should undergo training specific to the handling of space hardware. MTI should review and approve the drivers' qualifications and training. The board further recommended that a contingency plan be developed by MTI to cover any foreseeable transportation or handling incident. The final recommendation was that two escort vehicles accompany each transport of oversized hardware; one to be stationed in front of the trailer carrying the hardware, and the other to be stationed behind. The lead vehicle should be outfitted with a telescopic standard for height measurement to be set after actual measurement of the load.

LOSS OF ORION SOUNDING ROCKET WALLOPS FLIGHT FACILITY

During an intense thunderstorm on the evening of June 9, 1987, a single stage Orion sounding rocket and two 2 1/4-inch test rockets were inadvertently ignited and launched while on Pad 2 at the NASA Goddard/Wallops Flight Facility launch range in Virginia. The rocket and pad had been secured and personnel were in the blockhouse awaiting the passing of the storm, as per normal operating procedures. Three companion rockets, a two-stage Taurus-Orion and two small Super Loki-Datasonde meteorological rockets which were on the pad but on different launchers, were unharmed. The mishap was classified as a Type C.

The rockets were scheduled for launch during a 9:30 p.m. to midnight window to study nighttime thunderstorm effects on the ionosphere. On board the Orion rocket, which is about 16 feet long (including payload) and 14 inches in diameter, was an experiment from Pennsylvania State University designed to study how VLF radio waves emitted by lightning flashes propagate into the magnetosphere and cause high energy electrons to precipitate into the upper atmosphere.

Thousands of sounding rockets have been launched from the Wallops facility since the inception of operations in 1945. This was the first occurrence of this nature in over 40 years of operation.

FIRE DAMAGE TO TPS TILES ROCKWELL, DOWNEY, CALIFORNIA

On June 17, 1987, at the Rockwell International facility in Downey, California, three out of five TPS panels were destroyed during a test involving the exposure of the rewaterproofed test panels to a temperature/humidity environment. A malfunction of the humidity chamber caused overheating with a resultant internal fire that destroyed the three test panels. The mishap resulted in a loss of over $400,000.

An investigation revealed that a fail-safe feature, which first activates an audible alarm followed by a shutdown of the chamber, had not operated properly. This feature depends on an electrically tripped interrupt circuit breaker which was not in the tripped position at the time of the test. A loose crimp connection at the common terminal of the control interrupt device caused high resistance in the fail-safe circuit which prevented sufficient current flow to trip the circuit breaker. The crimp connection, routinely installed by the chamber manufacturer, has been a latent mode of failure since the chamber was delivered to the Rockwell labs. All other temperature and humidity chambers at the Rockwell labs have been inspected, and it has been verified that their previously installed independent/redundant fail-safe shutdown devices will prevent this type of failure.

ATLAS/CENTAUR 68 GROUND HANDLING MISHAP KENNEDY SPACE CENTER

During launch preparations at Launch Complex 36 Pad B for launch of the Atlas/Centaur 68, FLTSATCOM F-8 mission, an oxygen leak was discovered in the Centaur engine compartment. Removal of the Centaur stage was required to effect the repair.

On Monday morning, July 13, 1987, the demating of the Centaur stage from the Atlas began. At the time work stations on the service tower were manned, the bridge crane was positioned over the vehicle, and the lifting sling, nylon strap and hydraset were attached. Several platforms were retracted. The personnel required to observe the lift from inside the Centaur engine area entered the Interstage Adapter. Their primary responsibility was to ensure that no flight hardware was damaged as the hydrazine thrusters and Centaur engines cleared the interstage Adapter.

As a result of the GDSS review of the documentation to facilitate closing out the preparation requirements, the GDSS Quality Inspector questioned the proof dates on the nylon strap. It was determined that the inspector would have to look at the tag on the strap in order to verify the validation date. With the 28E platform retracted, access to the strap was difficult, and the tag was positioned such that it could not be read. The platform was extended and the sling relaxed approximately three feet. The bridge crane was then positioned at approximately one and one-half feet off-center to allow the crew access to the tag.

While this activity was in progress, it was determined that two other platforms should be further retracted to be completely out of the way for the demate task. With everyone's attention focused on the tag inspection, a mechanic, acting as both operator and observer, began a slow retraction of the platforms. During that operation, he heard a noise coming from one of the platforms and immediately stopped all movement to investigate. He noticed a portable workstand that had been positioned at the rear of platform now at the forward edge of the platform tilted toward the missile. The mechanic shouted for help, but before help could arrive, the workstand tumbled from the platform, hit another platform, and bounced into the Centaur liquid hydrogen tank which exploded. Because the sling had been slackened and offset to allow for the tag verification, the upper portion of the vehicle dropped and rotated. No serious injuries were incurred by anyone at the site. Damage to the last vehicle of this kind in NASA's inventory was estimated at $5M.

The investigation board determined that work practices had exhibited inadequate emphasis on procedural rigor and discipline. Program management was required to review safety precautions, requirements for operational discipline, responsibility assignments, procedures for consistency with approved facility configuration. In addition, program management was required to reassess the practice of using extensive markups of existing operating procedures and reanalyze quality and safety reports for trends.

THERMAL DAMAGE TO SRM AFT SEGMENT OF DM-8 MORTON-THIOKOL, WASATCH DIVISION

On August 30, 1987, after the successful firing of the DM-8, a "hot spot" on the bottom of the aft case segment where water from the deluge system was not reaching was noticed. Two garden hoses and a fire truck hose were used to spray water on the case. Later, evidence of out-of-contour case buldging due to the excessive heat was noticed and a twisted deluge system feed hose with two-thirds reduction in flow was discovered. At some time between then and two hours later, a 14-inch long through crack developed in the aft case segment. Damage to the segment was assessed at $1.4M.

The investigating team determined that the heat damage to the aft segment was caused by slag accumulation in the motor case as well as by the failure of the water deluge system to function properly. The team noted that design and operation of the deluge system used for DM-8 had received significantly less attention that had the successful DM-8 motor. In subsequent review of the actual operation of the deluge system, it was concluded that the system for the DM-8 was marginal even when operating as designed, excluding the mitigating circumstances of the twisted hose.

The investigating team recommended that the deluge system be designed, installed, inspected and tested according to Marshall Space Flight Center Facilities Engineering recommendations. As much redudancy as practical should be provided. The team also determined that it would be necessary to perform an "all up" test of the deluge system, spraying an aft case segment or a simulated segment, to verify adequate water coverage, pattern overlap and general satisfactory performance. In addition, a check of system performance, including flow monitoring at the nozzle manifold with nozzles plugged, is essential after the system is "final plumbed" before each firing.

MISSION FAILURE

ATLAS/CENTAUR-67 MISHAP

On March 26, 1987, the Atlas/Centaur-67 with a FLTSATCOM F-6 payload began to break up approximately 48.5 seconds after launch from the Kennedy Space Center and was destroyed by range safety officials approximately 20 seconds later. The vehicle was launched into adverse weather conditions--rain, clouds, and intense electrical fields--and triggered a lightning strike which resulted in the Centaur Digital Computer Unit's issuing an unplanned hardover booster engine gimbal command. The resulting excessive angle of attack created enormous dynamic loads during flight and resulted in the breakup of the vehicle.

In the opinion of the board, the most probable cause of the mission failure was launching the AC-67 vehicle into atmospheric conditions conductive to triggered lightning. The decision to launch in those conditions was seen as a violation of the established criteria used to avoid potential electrical hazards.

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